Mr. Bran Ferren

Bran Ferren is a nationally recognized award-winning designer/technologist working in theater, film, special effects, product design, architecture, and the sciences. He is currently President for Creative Technology and Research & Development at Walt Disney Imagineering. Walt Disney Imagineering is the theme park master planning, research and development, creative development, design, engineering, production, and project management subsidiary of the Walt Disney Company. Ferren's responsibilities comprise a broad range of assignments, including overseeing all R&D activities on both coasts.

Ferren heads up the Creative Technology Group at Walt Disney Imagineering, a resource for new technology invention and creative input for the entire company. Prior to his current position, Bran Ferren was a consultant to Walt Disney Imagineering while heading his own firm, Associates & Ferren. The company specialized in research and development, creative design, engineering, and execution of projects and systems for the visual and performing arts, as well as for industry and the sciences. A&F became part of Walt Disney Imagineering in 1993.

Ferren holds memberships on the Government-University-Industry Research Roundtable of the National Academy of Sciences and the International Design Conference in Aspen's (IDCA) Board of Directors. He is a member of the Army Science Board, the National Reconnaissance Organization Advisory Council, the National Security Agency Science Advisory Board, and the Senate Select Committee on Intelligence Technical Advisory Group. He is also a voting member of the Academy of Motion Picture Arts and Sciences, and the Academy of Television Arts and Sciences.

Ferren has won numerous awards for his work from the Academy of Motion Picture Arts and Sciences, the New York Drama Desk, the Los Angeles Critics' Circle, and the Maharam Foundation Annual Theater. A popular guest lecturer, Ferren has addressed over 100 professional groups in the entertainment, business, and scientific communities.

Ferren attended the Massachusetts Institute of Technology.

Submarine Information Technology

Bran Ferren
President, R&D and Creative Technology,
Walt Disney Imagineering

I am truly delighted to be here. I have had great pleasure and have built great admiration since I have worked with a number of people, Admiral DeMars and others in this audience, over the past year or two. You have my admiration and respect, and please treat any of my comments today as coming from that perspective!

I am going to talk to you based upon my *vast-at-sea* experience two days on the ALEXANDRIA. I think this qualifies me to speak in your behalf and to talk about your future! If I had to find the one thing that was most impressive to me about my trip out on the ALEXANDRIA, it was the superb quality and teamwork of the crew. I think the real asset you have on every single level is the quality of your people. That's what got you here, it's what's going to get you into the future, and I found that to be truly refreshing and remarkable because I don't see that in a lot of other places that I'm asked to visit. You should be very proud.

I'm not going to talk to you today about information superiority, about INFOSEC, about information management, and all of that stuff because it's really boring and lots of other people can talk to you about that. We are in the middle of a frenzy these days where people are providing really wonderful answers to the wrong sets of questions, so part of what I'm going to talk about is the process of asking the right questions, and I'll let you worry about getting the answers.

You can't or shouldn't talk about information technology without the top of your list being people, because all this other *junk* we have in computers and technologies—this computer

thing—is going to blow over relatively rapidly, and we will be left with something which is actually useful, intelligent, and helpful. You should not mistake the fact that any of the technology we currently have in computer technology is that—it's primitive, it's bad, it gets in the way of things rather than helping things, and the sooner we recognize it as being that, the better. At the same time we have nothing better, so part of our challenge is to learn how to manage through this rather embarrassing period in the evolution of computer technology until we get to some level of wisdom which, because the rate of change is accelerating so rapidly, will be sooner that anyone would imagine from looking at history to this point. It's not just changes *happening*, but the rate of change is *accelerating* in a way that we have never seen before in any area related to technology, with the possible exception of the first critical technology, which was language, which enabled us to cease becoming a herd animal and build a civilization.

The first half of this talk is going to be about people and leadership because I think *that* ultimately is the secret to success in information technology. The second half is going to be about my observations of what I've seen in the Submarine Fleet. And the third half will be about what I see as being the biggest challenges facing you! Interestingly enough, I just finished an intelligence community talk about a week ago, and I find the parallels between the challenges and opportunities facing the Submarine Fleet and the intelligence community to be quite remarkable. The notion of transitioning out of the Cold War way of thinking, of grappling with technology, of grappling with an aging population when the future is youth, is a very common set of challenges and issues.

Why focus on people rather than technology? It's very simple. We understand *exactly* where the technology is going. We have all sorts of really great rules of thumb, like Moore's Law, which reinterpreting what Gordon Moore said, is that at constant dollars the power of computation doubles every 18 months. People said the power of computation was going to run out 20 or 30 years ago; it didn't. People are now saying it will run out because of feature size and a whole bunch of other things; it won't. Just assume for the next 20 years you're going to have that increase in performance, and you'll be largely accurate. What you can't predict is social phenomena, cultural phenomena, and the sorts of things that we go to war for. Therefore that's the interesting area to focus on because it's the unpredictable domain.

Part of our challenge when we look to the future is to understand that our vision of the future on one level evolves, but at the same time comes back to things we know and understand. Why? Because fundamentally although our technology is changing very, very rapidly, we as humans are not. The same basic motivations of love, fear, passion—all the things that have motivated us for hundreds of thousands of years—still motivate us. Which is why, at the turn of the century, the vision of the utopian American society was a little house in the country with a green lawn and a white picket fence—it evolved through the Jetsons, it evolved through the General Electric house of the future, it evolved through a whole bunch of things. Right now it has evolved to, at the turn of the next century and, in fact, the millennium, the vision of a little house in the country with the lawn and white picket fence and an Internet terminal. We come back—we come back because we are motivated by the same basic human needs and desires. Incidentally, those desires are why we go to war.

I feel a bond with many of you in this room because you are the leaders who are going to make the sorts of changes necessary to keep this country and the way of life represented by the free world constant so that it is meaningful, so that it retains passion—and passion is the most valuable asset you have in this room—and so that it guides us into the future. Leadership and where leadership comes from is something I have studied a bit, and I find it fascinating and confusing.

There was a great study commissioned by another armed force that shall remain nameless—the Army—that looked for who makes the best leaders. What they wanted to find, using the traditional technique of scenario planning where you plot important axes against each other, was who makes the best leaders. The challenge was determining which axes are the most important determiners of leadership. The first axis they picked—and needless to say it has to be something that applies across an organization—was "smart to dumb." In every organization—in this room—one of you is the dumbest person, and one of you is the smartest. The other axis was "lazy to energetic," because the same thing applies. After a relatively minor extensive study, it was determined that if you're looking for the global leaders of tomorrow, you don't start with "lazy and dumb." At the same time it was kind of interesting because "dumb and energetic" turned out to be much worse when you reviewed the data; I will let you reach your own conclusions! It started to be counterintuitive for me because it turns out "smart and energetic" isn't so hot either. These people are a *big* pain in the neck; they get out, terrorize everybody, are really annoying, nothing is ever good enough for them, and you can't wait for them to get out of an organization. Turns out "smart and lazy" won because ultimately they make the best leaders. They delegate well, they certainly don't want to do all the work themselves, so they're happy to find people who do it for them. There's an old saying, "A's hire A's, but B's hire C's," and you see this in organizations. When you have the best and smartest people and the laziest leaders, they build phenomenally powerful organizations.

Now so what, why did this matter? Well, it gave me the impetus to start thinking about the kinds of people that build organizations and make decisions. There are, in fact, two kinds of people in the world—there are people who believe there are two kinds of people in the world and there are people who do not. However, of the two types of people who are most relevant to a lot of what we do and a lot of what you do, the first type I would call a "requirements person." Requirements people believe that you put together a team, a requirements team—you study the problem, you go talk to the customer, you listen to the customer, you look at past history, you look at the competition, you do research and development, you test it, you do focus groups, you do a whole bunch of things designed to get you a thing called a "requirements document." Once this is bought off on, you toss it over the transom to a bunch of people you've never met or seen before; they go act upon it, they build it, it gets tossed over to another bunch of people whose job it is to take it and use it. Sometimes these are contractors, sometimes government users—it varies. You then wait, and you get to see if it was any good. If it was great, everybody basks in the reflective glory of a process well done. Incidentally, you can tell if you're a requirements person in a requirements organization because requirements people tend to build requirements organizations. People make the vast mistake of building their organization based upon consensus—people that agree with them—rather than diversity—people who will challenge them—but that's a common to human behavior. But if you have viewgraph projectors in your conference rooms, you're a requirement organization—simple as that, and you know who you are! Now if the outcome is a great success, everybody's happy. If it isn't, you begin to search for the guilty party. The first thing you do is compare the end product with the requirements document. If they agree, you kill the requirements team because they clearly didn't take their job seriously or were not competent enough to the task. If they don't agree, you kill the contractor because clearly they were irresponsible, spending your taxpayers' money irresponsibly, and bad human beings.

Incidentally there's a *big* thing these days about bringing creativity into requirements driven organizations. Understand that in many requirements organizations, this is not only undesirable but inappropriate. For example, if you manufacture penicillin for a living, do you want every employee on the production line leaving a mark on the molecular structure of the drug? The answer is probably not; to acknowledge their creativity isn't necessarily helpful and is often destructive as a good first step.

The second type of person I would call a “big idea” person. Big idea people are different. They would never dream of talking to the customer because all you get from talking to customers is minor incremental events, as they are bound and trapped by what they know. Instead, you get people who are a lot smarter who just figure it out and say “trust us they’re going to love it when they get it.” Big idea people don’t believe in the high watermarks of the requirements process or freezing the requirements early. They think it’s a crime against nature to freeze a requirement because it precludes the ability of continuous improvement—the notion that you constantly iterate, make things better as you go, including even after they ship. Big idea people don’t believe in metrics because their notion is that what they do is largely qualitative, and by definition you can’t apply metrics to a qualitative process.

Interestingly enough, the most effective organizations—and I would argue a necessity for organizations that will survive in the future—are those that can combine big idea thinking and requirements thinking. We’re one of them, and incidentally Imagineering is 48 years old, so fairly comparable with this organization. We build theme parks that cost billions of dollars. They’re built out of bricks, mortars, bits, bytes, and electrons, and if you don’t put them in the right place in the right sequence, you go over budget and you don’t open on time. At the same time if you finish under budget and ahead of schedule and it’s boring, our business model collapses because we make all our money in the last ten percent which is typical in theme and entertainment businesses.

Now what’s the problem? So you just get some big idea people and requirements people; you put them together. Here’s the problem—they hate each other. They despise the ground the other walks on. Requirements people think big idea people are irresponsible, out of control, undisciplined, incapable of being team players, dress funny, etc., etc. I won’t elaborate much on what big idea people think about requirements people, other than to say they believe it drains the life force out of the room to merely have one present. Big idea people treat this idea that requirements people talk about—“out of the box” thinking—with great amusement because it never occurred to them there was a box. It’s only requirements people who believe there is a box that you have to think out of.

Why is this relevant? Because, again, our success and your success depend upon combining big idea thinking and requirements thinking. The success of the United States of America depended upon it, and there was a big idea called the Bill of Rights. How is it that a set of instructions for how to run a nation that’s 200 years old is working as well or better today than when it was instituted? How many of your processes and procedures or specifications or protocols work well two years later, five years later, when they are delivered? It’s because it’s a different philosophy; it’s underpinning the very fundamental set of why human beings should react to each other in a civil way to proceed with an orderly society. It gives you the flexibility for dissent, it gives you the ability to change your mind and refine things, it has provisions for all of that.

The idea of the nuclear Navy and the nuclear Submarine Fleet was a big idea. It was not obvious, it was not straightforward, it was not just a matter of engineering—it was a big idea. The reason we did as well as we did in Iraq and are now having as few lives lost in what we’re doing in Kosovo was because of an Army general’s idea called “Own the Night.” Very simply stated, he wants to be able to fight as well at night as he does in the daytime. That’s a big idea, and with it all of the people who work on radar, electro-optics, and everything else can develop the series of requirements necessary to be successful.

Part of the challenge here is that big ideas are always expressed as one sentence. It might be a compound run-on sentence, but it’s one sentence, and that sentence is one of the essential

components of leadership. The first challenge is identifying the vision; the second one is articulating it and motivating people to do things they never believed they could do before. What I would argue you need is a vision for information technology and the next 50 years of the nuclear Navy and the nuclear Submarine Fleet. Part of the challenge is it's hard to do this type of thinking, and it's almost impossible to do it inside organizations that require consensus because individuals are trapped by their own experience.

When I was on the ALEXANDRIA, which was a great experience, I was struck that there are two different types of people who designed the ALEXANDRIA. One type was propulsion people, and the other type was everyone else. Propulsion won, because when you look at the back of the boat and compare it to the front of the boat, the back of the boat is a beautifully designed, conceptualized, and implemented system. Clearly systems engineering ruled: it was beautifully integrated; things were not covered up to make them pretty but they were designed to be accessible; things were intuitive to one skilled in the art as to what they did and how they did it, and so forth. You go to the front of the boat—the command and control area—and it looks like a weekend at Radio Shack and a meg welder. Basically, the philosophy seemed to be that electronic technology and information technology make a nice decorative contribution, but shouldn't otherwise interfere with the operation of the boat.

Now at some time in the past this may have been a sensible perspective and in fact, I would argue, as recently as 20 years ago. And you know, seawater and high performance electronics—it's not a good thing to start with. The idea of these narrow-band interfaces like CRTs and other things—all of it seems perfectly sensible. What happened as this technology was introduced is we got a progressively better series of nice boxes that all independently work reasonably well, don't talk to each other, aren't integrated, and most importantly, aren't integrated into the sensibility of the people in the leadership position. They are a decoration for the command and control system.

Now if you're thinking that you're at an advanced stage of digital technology, you're no better off than any of the rest of us are—that's primitive junk! It's important to remember that because we are at a very primitive stage in the evolution of digital technology. I would argue what is known about acoustics relative to the Submarine Fleet is barely known. You think it has gone as far as it can go—I would argue that why do you think the head of IBM, Watson, when he was asked what the potential market for computers was, answered "five or six" when they introduced the first mainframe computer. That's where you are in understanding undersea acoustics. If you believe that you have a sophisticated knowledge of it, if you believe the mission is training people to understand decibels, acoustics, and propagation phenomena, you're wrong. Machines should understand that, not people. People should have the information presented to them in such a way that they can naturally assimilate it.

There is a terribly dangerous fiction that the big danger for the war fighter—and it's not just submariners but everyone else—is information overload. These poor people—their brains are going to crumble if they get another little bit of information and you've just got to filter it, simplify it, make it more basic. Nonsense! If you digitized this room at the resolution that a human being can perceive it and move around in it, this would be somewhere between 100 terabytes, 10 pedibytes, somewhere in that range of information. Any of you have trouble downloading a 100 terabyte data base when you came in here this morning? Did you have trouble understanding the use of the seat? Was there any ambiguity about which way to face? When someone talked to you, did you have to understand and recognize all the people in the room to be able to parse who it was and what they were saying to you? No, because this information is presented to you in a way that millions of years of genetic and biological history has attuned you to be able to deal with.

The challenge in information technology in submarines is to get the information presented to the war fighters in such a way that it is natural to the way they process information, so that if a target is over there and it's acoustic, it sounds like it's coming from over there rather than some ambiguous place. We have taken the ability for human beings to grasp abstraction, which was one of our great gifts, and used it as a weapon against our own effectiveness. The fact that we can grasp abstraction means we can read and write because there's no logical extension of language that gives you reading and writing. It's a pure abstraction, and we parse things in multiple layers (some other talk I can talk to you about that) because it's a complete abstraction yet we've learned it. I would also argue incidentally that it's a fad and in 250 years we won't be reading and writing; it will have been replaced by something better because it is an abstraction and therefore it's vulnerable.

What's natural is the way we process language. What's natural is the ability to do sensor fusion. We talk about automatic target recognition—it's all nonsense. The only system that's ever been able to do that is a human being. Why? Because there is a big difference between information and knowledge, and while there is an explosion of information going on at the moment, there's no such explosion of knowledge. The amount of good guys, bad guys, countries, square miles on the planet is all largely the same. So if you're thinking about it as this huge increase of needles in haystacks, you're wrong. In the needle and haystack analogy, we are dealing with finding a constant number of needles and having exponential growth of hay. A scientist would say the signal-to-noise ratio is deteriorating. One of the critical things to understand in information systems is that your challenge is not processing that. It's also not filtering, because filtering is a flawed concept. Until we can do context based filtering, the stuff that you care about in this world is not the stuff you knew about in advance. Every technique we use in the submarine these days to reduce the amount of information, because of this false belief that we need to give a person less information, is based upon only passing through what we understand. But nothing in life that's interesting is something that you understood before. The novel stuff and the stuff you need to know as a war fighter is that which you've never seen before. Our information systems won't pass that at the moment; they filter it out because they don't know the difference between it and noise. At the moment, there's only one system that will do context based analysis information—a human being.

Now, why is this relevant? Because when I was on the submarine, I had *no clue* as to where I was. None of the information systems made any sense for me to get at that. If I'd had a window, it would have helped. I could have looked out and said at least I was under water. I didn't know; there isn't a light that goes on that says "you're under water." The fact is you have no sense of where you are. You can talk all you want about battle space and information display and so on, but at the same time we make it so abstract, you don't know where you are. Certain people have the ability to think in three-dimensional space; they can work through these abstractions, but they are a very isolated group. The promise of information technology, not at the primitive state we have now but later when we do ultra wide-band interfaces to human beings, is to relieve this, to give us a sense of where we are and what's going on in a way that millions of years of genetics help us to appreciate.

The ALEXANDRIA did a maneuver where it surfaces quickly-(emergency blow, which in our industry has a whole different connotation). They explained to me that we were going to surface as quickly as you possibly can—hold on and so on and so forth-deafening noise, everything's happening, everybody's looking at each other. Twenty percent of the people on the crew had never been out at sea, and this was pretty impressive. You're leaning back, and you're image is that this thing is rocketing skyward. We break the surface and then lay over-very impressive. Well, you know, think about it folks. The boat is 600 feet long, and we were 600

feet down. All the boat did was lay on its side, poke its nose out, and fall over. But you have no sense of that; you think all hell is breaking loose. You know, the boat is longer than the depth we were down, for goodness sake. Do you think if you submerged under the water five and a half feet and then blew your way to the top, anyone would be impressed? I mean, let's get real here!

At the moment all of the thinking that I see going on submarines is analog thinking. Not surprising—the ocean is analog, people are analog—they think analog. And as long as you think that the digital stuff is designed to complement the analog rather than fundamentally be the intellectual space—the decision space—that you're working in, it's going to remain like that. I don't want to criticize what I saw on the boat because I see it as enormous promise. I think we can start to understand, however, that the most valuable technology we have on our submarines at the moment is the human beings, and understand that the problem with the way we're dealing with information technology is we have a whole variety of sensors—some smart, some dumb. These sensors give us an enormous bandwidth of information, so the front end signal processors take this bandwidth and reduce it down. Smart people sitting at some Navy lab then figure out what signatures are, Doppler components, and all sorts of other things, and they reduce it down. After that other people say, "Well, you know, we have operational protocols, we have to divide it up"-they do a bunch of things. These get further reduced down to successively smaller paths of information until there's a sonar display, there's a position display, and so on. Then this interfaces to a human being, the only ultra live-band multiple data path knowledge extraction parsing system ever developed.

Now as engineers, or as leaders, where do you think the problem is in the information flow here? This is not *subtle*. This is a crime, and what you're talking about doing now is making it *smaller* because of information overload. It makes no sense at all. The strategy needs to be to get wideband interfaces into the human being, put people in collaborative information spaces. Right now I could say, "Quick! Let's find out what fire protection is in this room." By observation, we can instantly put together a relatively good first guess at what the total fire control management system for this room is. We can talk to each other collaboratively. I can say, "Gee, look over there. Am I missing a firebox? Is there one around the corner?" Instantly someone can tell me, and we can very quickly synthesize out of all this information terabytes of data. We don't have to sort through a pedibyte of data and do data analysis and reduction. We just all look at the room; we talk to each other. You log it, you appoint someone to keep an eye on it, and you move on.

This isn't hard. It's only hard if you turn it into a bunch of technical mumbo jumbo about bit rates and bandwidth—all of that other stuff. It's just nonsense. You know that any time someone says the future of sonar is ultra narrow band, you know that the future is probably ultra wide band. You're doing stuff in the narrow band space just because it's easier to think of algorithmically, but obviously it's going to be more robust to be active low energy ultra wide band and basically let sea state and background noise be your active sources. This has been known forever, but it's too hard to think about because we don't understand how to process incoherent nonlinear information. The human brain does, and if you can present this in a way that the human brain can naturally accept, you have a shot at it.

This culture of awareness and information overload, standardized interfaces—don't get me started on standardized interfaces—we're now saying we need common operating environments, we need all this other stuff. It's all nonsense. High performance people doing high performance jobs need custom interfaces, not COTS standardized interfacing. Put all the COTS in the middle ware, but the interface to anyone doing a high performance job needs to be custom. Why? Because in the entire history of our planet, that has always been what works. Do you think it's

intuitive to fly an F-16? Is it intuitive to play a piano? Is it intuitive to drive one of those racing cars? Is it intuitive to do any of the high performance tasks that a human being has ever done? No—yet we think the same information technology that my secretary has at the office is good enough for your war fighters to be able to win the war. I don't buy it. If it is the case, it is the only time in the history of human high performance tasks that it has been the case. Getting over believing this stuff is really, really important. Customizing the interface to the task and the sensibilities of the people is critical.

Let's think about what the Submarine Fleet is going to be like 50 to 100 years from now. I think it's fair to do that, pretty easy to predict. Two hundred knot speeds will be commonplace, routine, straightforward. The notion of constellations as orbital constellations that exist up above in our overhead world will exist in the sea. They will start out as being large physical objects, then become micro, then become nanotechnology, but all of the problems with communication command and control—reconfigurability, networking, and so forth—will be solved by undersea constellations. It's a given.

Active sonar will be the rule, not passive. Active sonar has a low probability of intercept and so on, but generally speaking sonar thought of in isolation is always doomed. Sonar thought of as part of a fusion environment with other undersea phenomena, most of which we don't understand—that's entirely sensible. The mistake people make is thinking computers work the way people do. They don't. Computers slow down when you give them more information; we solve problems faster with more information. If we tried to understand this room's fire control management system by plugging our ears, looking through a soda straw, and not being able to touch or see anyone around, that exercise would be much, much harder to do. At the same time, that's what you're doing to everyone in the information space on a submarine at the moment. You're making people look at the world through a soda straw. It's just not sensible.

Even though one great strength of submariners has been their autonomous independence, spirit, and passion—and this independence has kept them strong—it's time to take that independence and wire it up to the rest. It doesn't mean giving up your independence, it doesn't mean giving up your spirit, but it means you're participating in the larger information space. If you are not included, you will not be able to make the same depth of contribution that you can otherwise.

Reconfigurable technical and physical architectures will happen 50 to 100 years from now, where basically ships' hulls technical systems will simply reconfigure themselves on a mems and then nanotechnology level to suit the task ahead—change their hydrodynamics, change their acoustic propagation, change a whole bunch of things—their electronic properties, their optical properties before it. Probably the Navy will be privatized, but that's the subject of another talk.

What are the big challenges ahead? I think the first one is vision—you need to recapture a single sentence vision of why you're doing all of this. I would argue that the vision is going to be in information technology, that ultimately the same fundamental technical impetus that nuclear propulsion provided the Submarine Fleet for the last 50 years—when it arrived and how it arrived—will be the same sort of engine that drives you in the future. Information technology is where you can make nonlinear advances over other people playing in the same field. The ability to believe that, the ability to get people to deal with that, I think, is essential to taking that vision and bringing it to reality. Vision is an essential component of leadership. You cannot lead without vision, and I would argue that the subtleties of vision are still there, but the final vision, the point that takes all of these activities and lets them converge to a point of meaning and synthesis, that is missing. You have to recapture it and rediscover it, because without it, you won't deal with the other elements.

What are the other elements? A big one is talent. If you are not capable of attracting, hiring, and retaining the best people in the world, you're doomed. At the moment, the best people in the world in information technology are not going into the Navy, and they are not going into the Submarine Fleet. They're going into Silicon Valley start-ups; they're going into Microsoft; they're going into Disney; they're going into a whole bunch of other companies who have a vision that the kids are buying into. The fact that there are no kids in this room should give you a loud and clear message that there's something wrong, and we need to pay attention to it. Without talent, it will not work. If you believe that information technology and mastery of it can be as important as nuclear propulsion was for the future of the Submarine Fleet, that's a problem you have to address as if it were your most critical emergency. You should think of it as being the top priority.

Second one—it's a big problem—it's called trust. In this country, the American people do not trust their government and by extension, they do not trust the Navy. The Navy doesn't even trust the Submarine Fleet, depending upon whom you ask. If you cannot restore that sense of trust, you will not get the vote of confidence of the dollars in funding necessary to carry out your mission. The ability to maintain that balance of passion, autonomy, and independence, but at the same time restore trust, is critically important. You can't do it without the talent, but once you have the talent, that's job one.

Connectivity—this idea of how do you maintain independence but become connected to the larger information space—is critically important. I don't think there's anything that's more important. It will require change. However, we don't like change. And if there is a sobering sense of doom and gloom lurking in the back of your mind, it is because you have some real issues. I don't think you have really big issues; I think you have the same issues all of us face. But what I think you have to do is recapture the vision so that you have a source of passion that can move you forward into the future. Understand that by definition you are genetically inherited of a gene that resists change—if you feel something changing you will reject it. That's what you do as individuals; that's what your organization does because it's staffed by humans. Understand that that type of discomfort is a good discomfort, and you'll always want to have it. The type of discomfort that comes from lack of vision—that you can fix. The other one you're born with—learn to like it.

I thought there was an excellent point made earlier, and it was on my list as well-complexity. I have a slightly different take on complexity because I believe that starting 15 to 20 years ago, all the technical systems you are using became more complicated that any human being can understand. Yet, the methodology that you're using is still based upon complete understanding—whether it's complete understanding of an enemy, or of a reactor, or a computer system. Nobody understands how computer systems work now. There's no one at Intel who knows how an Intel chip works. They understand the general concept, but it was CAD systems running simulations by the other CAD systems that built that chip. Do you think anyone looking at the chip could say, "That transistor doesn't belong there?" No, they have no clue. Just as nobody understands what all the millions and millions of code in an operating system do. Realize you're never going to be able to understand how things work so that you can validate them against a known model, and therefore you need a different set of rules and a different set of tools.

There is one additional thing that I would like to talk about because I think it's a bigger issue than any of the issues I've discussed, and it's fundamental to your success. It's a problem that's bigger than war, and bigger than crime, and bigger than drugs, and bigger than AIDS, and bigger than overpopulation and overcrowding—it's called education. The idea that we of the free and intelligent world, and in particular this country, have allowed the state of education to reach the state of decline that it has in the U.S. is a real crime. The fact that the most sophisticated

technology in any inner city school in this country is the metal detector that frisks kids for weapons when they go into the building ought to be fundamentally unacceptable.

The Internet is probably, I would argue, the most important technological contribution to the humankind since language. Why? Because it's the most important story telling technology that's ever been introduced. Every time a story telling technology, whether it's language, reading, writing, moveable type, newspapers, telephone, telegraph—you go down the list—every time one of these has been introduced, it has changed the direction and the course of society, and it has become largely permanent. The Internet will be the most effective story telling medium ever, which means 1) it's going to be the most important for us as entertainment medium, and 2) it's going to be the most important leadership medium, because leadership is about story telling. You have never met a great leader who is not a great storyteller—doesn't matter if it's political leader, military leader, or a teacher you remember from school. And that's the final point—teacher—because teaching is about story telling.

Now story telling in the command and control situation is how you will get a three-dimensional, four-dimensional picture of what is going on and what is happening. At the same time, that same technology will turn inward to our schools—an electronic book that fits in the palm of your hand powered by solar energy connected to the Internet by a satellite and costing less than a textbook, capable of speaking in any language because it does autonomous translation and transliteration—this is the greatest gift to information space management, to education, that the world has ever seen. I'm not talking about replacing teachers with computers, because if you think that happens, you don't know what teachers do or you don't know what computers do, or both. I'm talking about providing "power steering." It's power steering so that the message of one great teacher can reach many. It's power steering for you so that your great leaders and people with unique insight can reach many in a real time and continuous manner.

Our kids are our future—the future of the Submarine Fleet, the future of the nation, the future of the world. If you don't start believing as individual citizens of your respective countries that education is your top priority, you're going to have a community of dummies. That's not what you're going to need to capture your vision. If you can retain your independence, if you can retain your passion—realizing that you've barely scratched the surface on what is possible in submarine warfare defense, you've barely scratched the surface of what is possible in information technology, and realizing the role and contribution that you can play not just to maintaining an intelligent and educated Navy and Submarine Fleet, but an intelligent and educated planet—we will have a real future to look to.